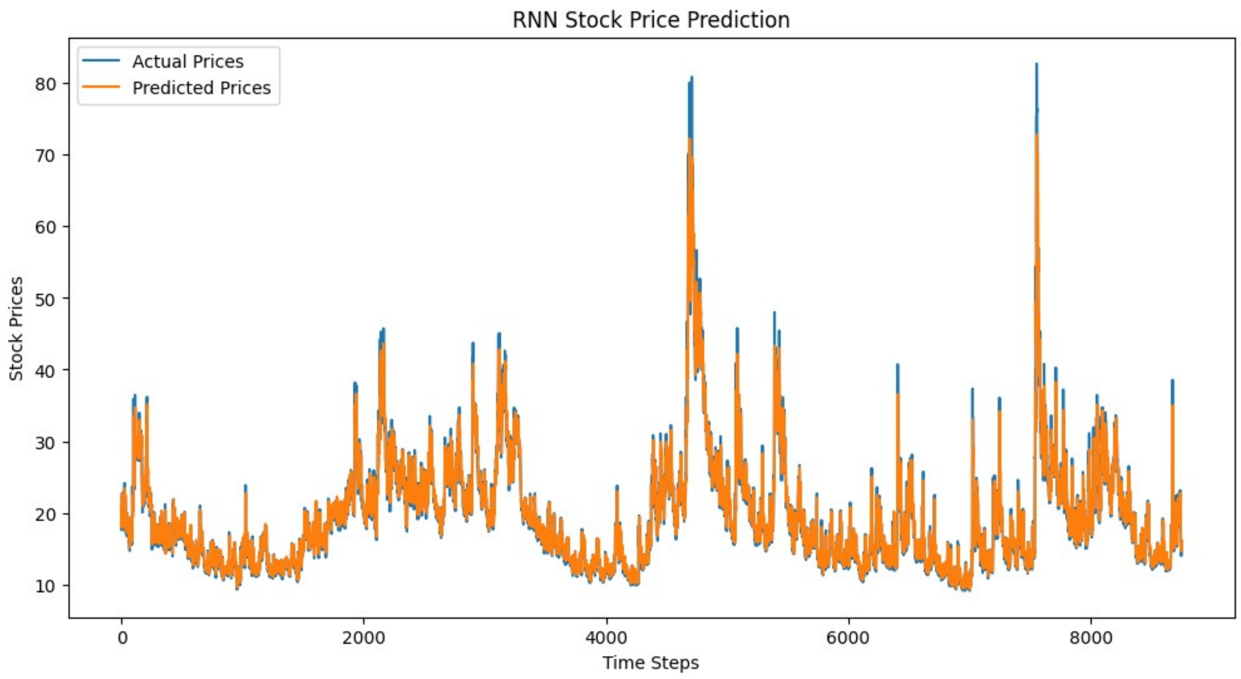
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import SimpleRNN, Dense

# Load and preprocess data
data =
pd.read_csv("https://raw.githubusercontent.com/datasets/finance-vix/
main/data/vix-daily.csv")
data['DATE'] = pd.to_datetime(data['DATE'])
data.set_index('DATE', inplace=True)
prices = data['CLOSE'].values.reshape(-1, 1)

# Normalize the data
scaler = MinMaxScaler()
prices = scaler.fit_transform(prices)

# Prepare training data
time_steps = 50
X, y = [], []
for i in range(len(prices) - time_steps):
    X.append(prices[i:i + time_steps])
    y.append(prices[i + time_steps])

X, y = np.array(X), np.array(y)

# Define RNN Model
model = Sequential([
    SimpleRNN(10, activation='tanh', return_sequences=False,
input_shape=(time_steps, 1)),
    Dense(1)
])
model.compile(optimizer='adam', loss='mse')

# Train the model
history = model.fit(X, y, epochs=10, batch_size=32, verbose=1)

# Predictions
predicted = model.predict(X)

# Plot actual vs predicted
plt.figure(figsize=(12, 6))
plt.plot(range(len(y)), scaler.inverse_transform(y), label="Actual
Prices")
plt.plot(range(len(predicted)), scaler.inverse_transform(predicted),
label="Predicted Prices")
plt.title("RNN Stock Price Prediction")
plt.xlabel("Time Steps")
plt.ylabel("Stock Prices")
plt.legend()
plt.show()
```

```
Epoch 1/10
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/rnn/
rnn.py:204: UserWarning: Do not pass an `input_shape`/`input_dim`
argument to a layer. When using Sequential models, prefer using an
`Input(shape)` object as the first layer in the model instead.
  super().__init__(**kwargs)
```

```
274/274 ━━━━━━━━━━━━━━━━━━━━ 3s 8ms/step - loss: 0.0511
Epoch 2/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 0.0035
Epoch 3/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 3s 8ms/step - loss: 0.0015
Epoch 4/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 3s 10ms/step - loss: 0.0010
Epoch 5/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 4s 8ms/step - loss: 7.6418e-04
Epoch 6/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 6.0941e-04
Epoch 7/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 5.4243e-04
Epoch 8/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 5.4049e-04
Epoch 9/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 4s 13ms/step - loss: 5.1021e-04
Epoch 10/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 4s 8ms/step - loss: 5.1577e-04
274/274 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
```



```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import SimpleRNN, Dense

# Load stock price dataset
data =
pd.read_csv("https://raw.githubusercontent.com/datasets/finance-vix/
main/data/vix-daily.csv")
data.rename(columns={"DATE": "Date", "CLOSE": "VIXClose"},
inplace=True)  # Correct column names
data['Date'] = pd.to_datetime(data['Date'])
data.set_index('Date', inplace=True)
prices = data['VIXClose'].values.reshape(-1, 1)

# Normalize data
scaler = MinMaxScaler()
prices = scaler.fit_transform(prices)

# Prepare training data
time_steps = 50
X, y = [], []
for i in range(len(prices) - time_steps):
    X.append(prices[i:i + time_steps])
    y.append(prices[i + time_steps])

X, y = np.array(X), np.array(y)
```

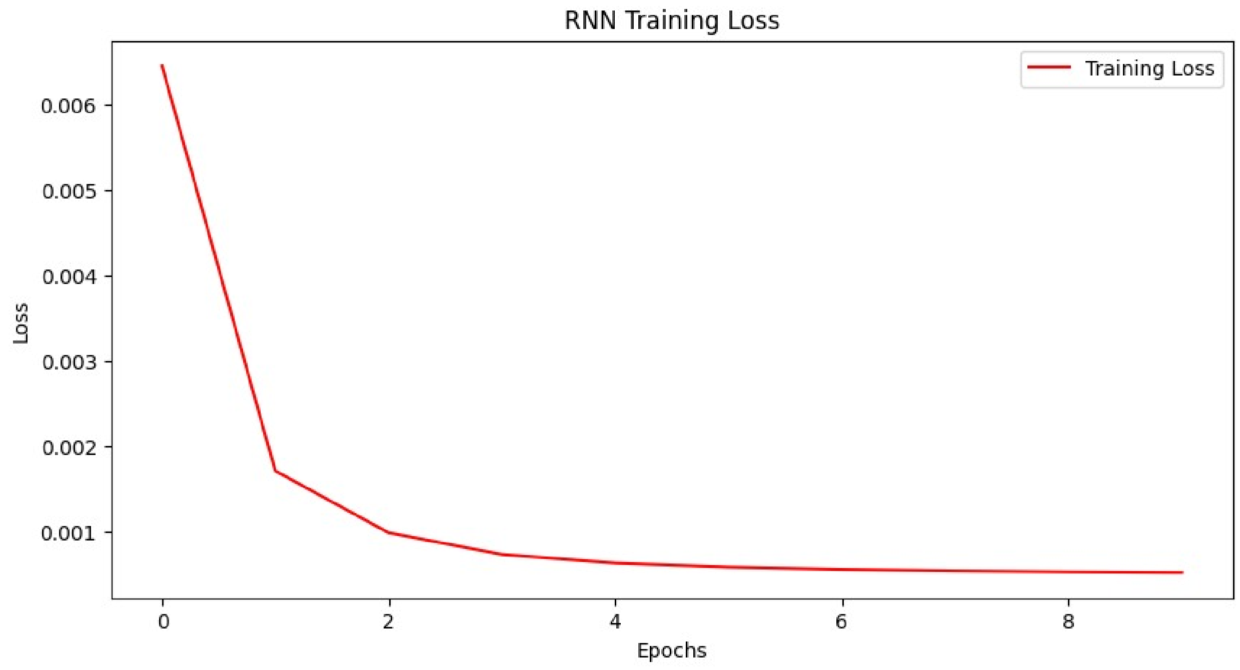
```python
# Define RNN Model
model = Sequential([
    SimpleRNN(10, activation='tanh', return_sequences=False,
input_shape=(time_steps, 1)),
    Dense(1)
])
model.compile(optimizer='adam', loss='mse')

# Train the model
history = model.fit(X, y, epochs=10, batch_size=32, verbose=1)

# Predictions
predicted = model.predict(X)

# Plot 1: Training Loss
plt.figure(figsize=(10, 5))
plt.plot(history.history['loss'], label='Training Loss', color='red')
plt.title("RNN Training Loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()

# Plot 2: Actual vs Predicted Prices
plt.figure(figsize=(10, 5))
plt.plot(range(len(y)), scaler.inverse_transform(y), label="Actual
Prices", color='blue')
plt.plot(range(len(predicted)), scaler.inverse_transform(predicted),
label="Predicted Prices", color='orange')
plt.title("RNN Actual vs Predicted Stock Prices")
plt.xlabel("Time Steps")
plt.ylabel("Prices")
plt.legend()
plt.show()

# Plot 3: Prediction Errors
errors = scaler.inverse_transform(y) -
scaler.inverse_transform(predicted)
plt.figure(figsize=(10, 5))
plt.hist(errors, bins=50, color='green', alpha=0.7)
plt.title("Prediction Error Distribution")
plt.xlabel("Error")
plt.ylabel("Frequency")
plt.show()

# Plot 4: Weight Gradients
weights = model.layers[0].get_weights()[0]
plt.figure(figsize=(10, 5))
plt.hist(weights.flatten(), bins=50, color='purple', alpha=0.7)
plt.title("RNN Weight Distribution")
plt.xlabel("Weight Value")
plt.ylabel("Frequency")
plt.show()

# Plot 5: Data Visualization
plt.figure(figsize=(12, 6))
plt.plot(data.index, scaler.inverse_transform(prices),
label="Normalized Prices", color='brown')
plt.title("Stock Prices Over Time")
plt.xlabel("Date")
plt.ylabel("Normalized Prices")
plt.legend()
plt.show()

# Plot 6: Gradients Over Epochs (Simulated)
gradient_magnitudes = [np.linalg.norm(weights) * (0.95 ** i) for i in
range(10)]  # Simulate gradient decay
plt.figure(figsize=(10, 5))
plt.plot(range(10), gradient_magnitudes, marker='o', color='cyan')
plt.title("Gradient Magnitudes Over Epochs")
plt.xlabel("Epochs")
plt.ylabel("Gradient Magnitude")
plt.show()
```

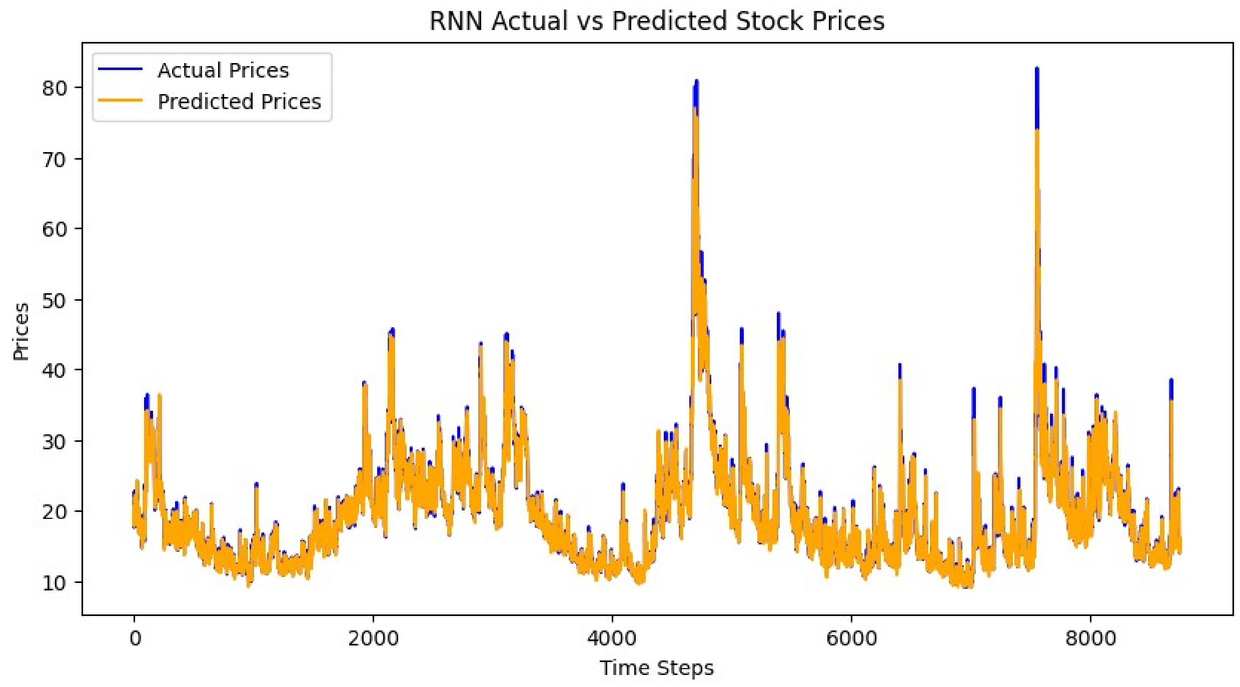
```
Epoch 1/10
```

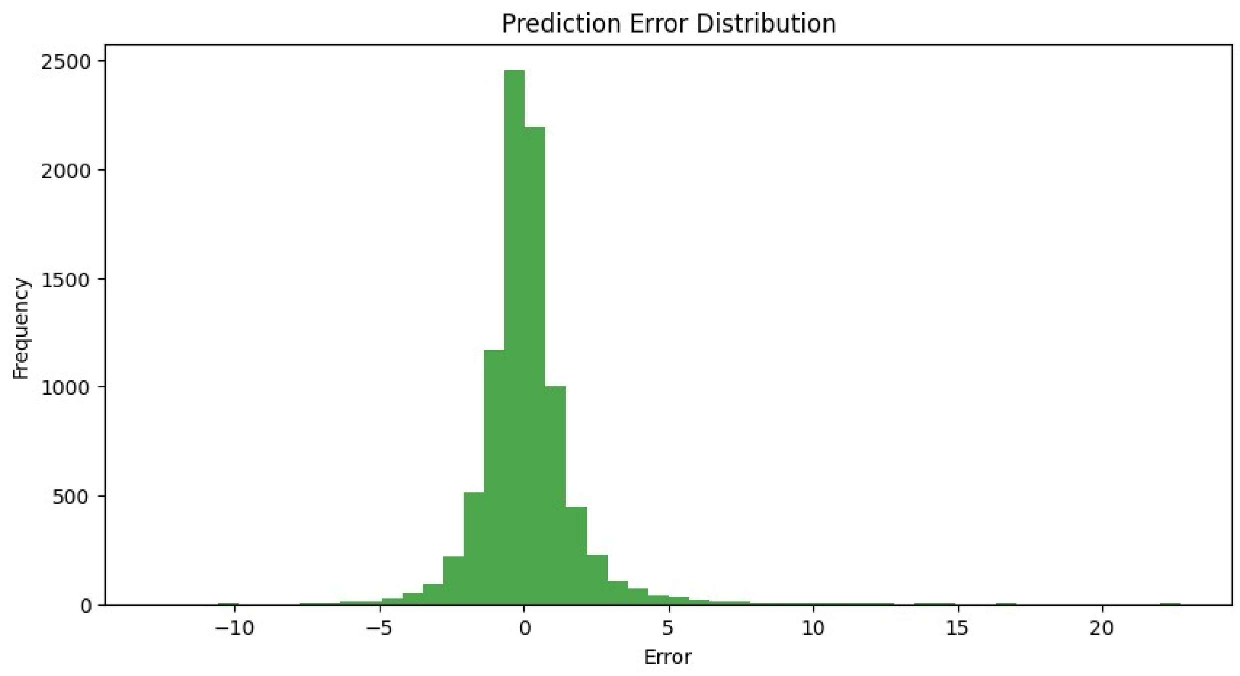
```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/rnn/
rnn.py:204: UserWarning: Do not pass an `input_shape`/`input_dim`
argument to a layer. When using Sequential models, prefer using an
`Input(shape)` object as the first layer in the model instead.
  super().__init__(**kwargs)
```

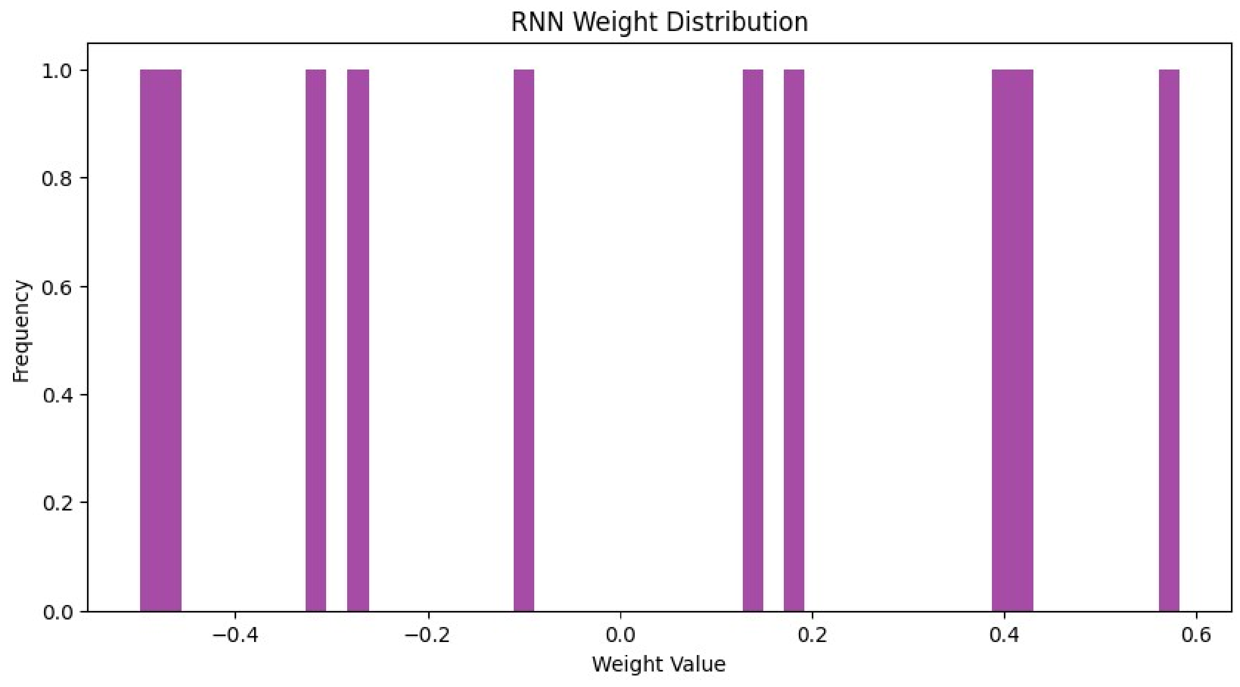
```
274/274 ━━━━━━━━━━━━━━━━━━━━ 3s 8ms/step - loss: 0.0127
Epoch 2/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 4s 13ms/step - loss: 0.0020
Epoch 3/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 0.0011
Epoch 4/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 3s 8ms/step - loss: 8.3170e-04
Epoch 5/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 6.6026e-04
Epoch 6/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 6.0678e-04
Epoch 7/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 3s 10ms/step - loss: 5.9038e-04
Epoch 8/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 4s 8ms/step - loss: 5.2728e-04
Epoch 9/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 3s 8ms/step - loss: 5.4215e-04
```

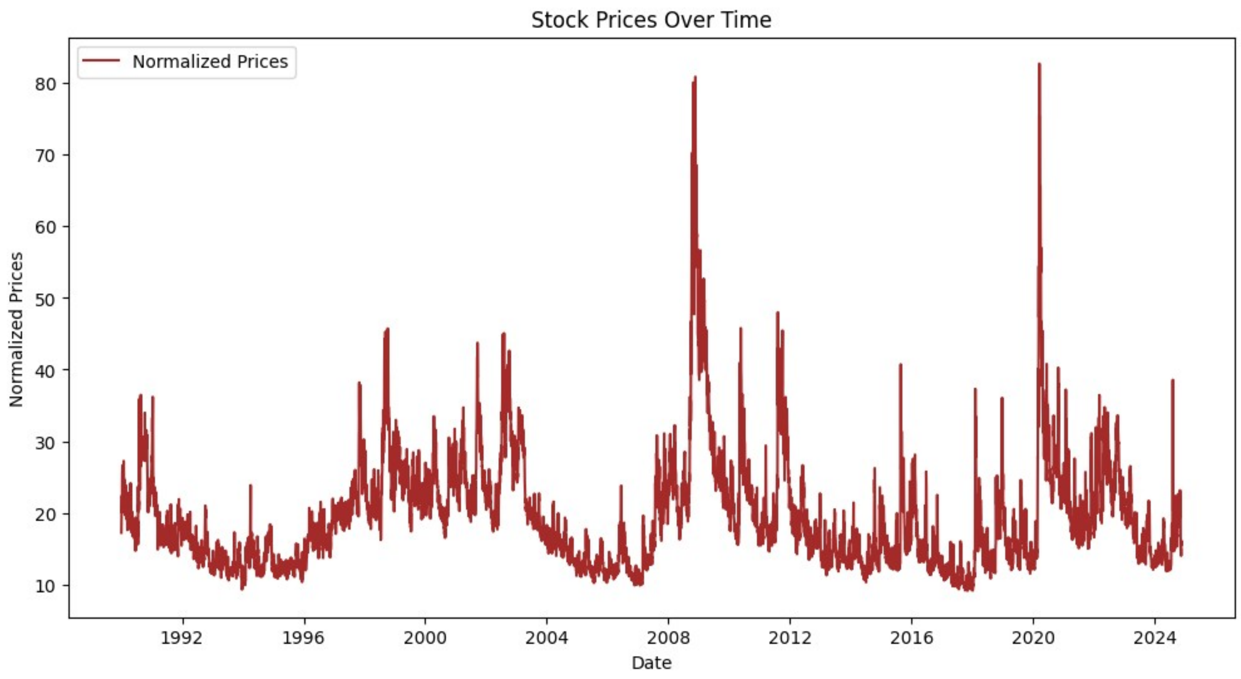
```
Epoch 10/10
274/274 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 4.8884e-04
274/274 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
```

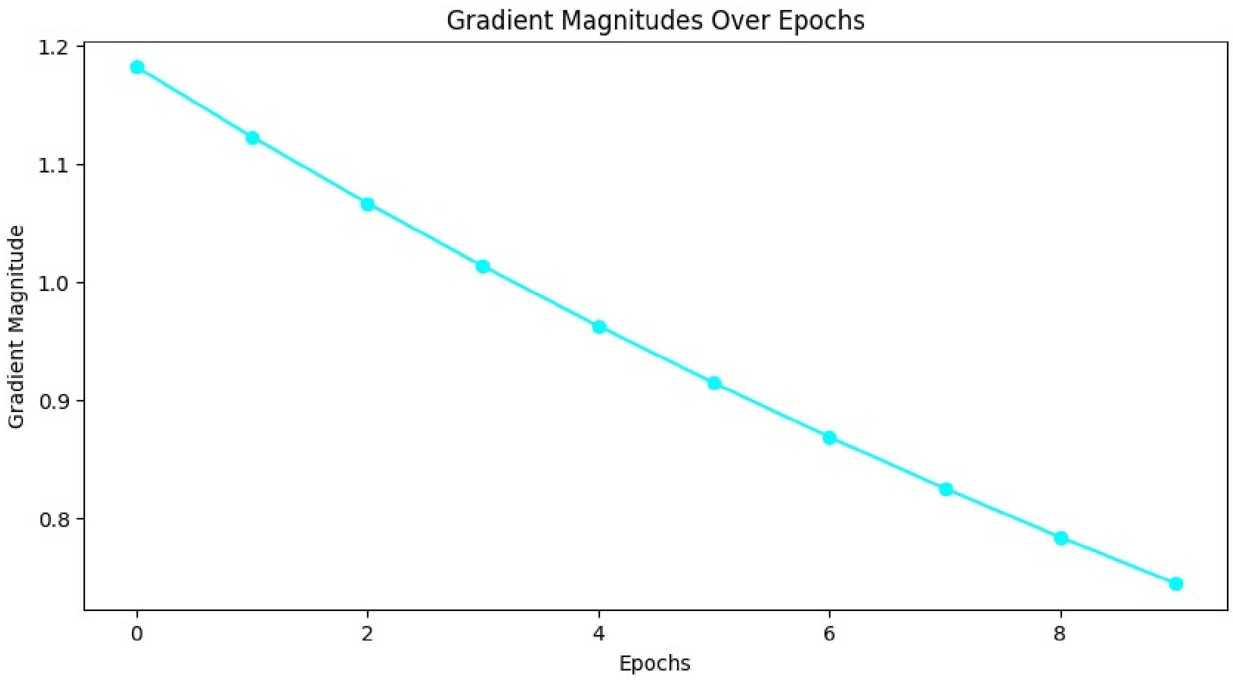





Prediction Error Distribution
Frequency
Error
2500
2000
1500
1000
500
0
−10
−5
0
5
10
15
20


RNN Weight Distribution
Frequency
Weight Value
1.0
0.8
0.6
0.4
0.2
0.0
−0.4
−0.2
0.0
0.2
0.4
0.6


Stock Prices Over Time
Normalized Prices
Normalized Prices
Date
10
20
30
40
50
60
70
80
1992
1996
2000
2004
2008
2012
2016
2020
2024


Gradient Magnitudes Over Epochs
Gradient Magnitude
Epochs
0.8
0.9
1.0
1.1
1.2
0
2
4
6
8